

receiver filter functions 360 comprises output signals $a^{(i)}(n)$ and $a^{(j)}(n)$.

These output signals may be switched at a rate of $1/T$ to produce corresponding signals \hat{a} to $i(n)$ and \hat{a} to $j(n)$.

Since $H(f)$ is unknown, direct computation of $P(f)$ is not feasible, since 5 the matrix $P(f)$ depends on the impairment matrix $H(f)$. However, $P(f)$ is found based on iterative methods according to an embodiment of the invention. By starting with $\tilde{P}(f)$ in place of $P(f)$ and $\tilde{P}(f)$ until the mean-square-error at the slicer of receiver 108 is minimized, then $\tilde{P}(f)$ is a reasonable first approximation of $P(f)$. $H(f)$ cannot necessarily be predicted accurately. A 10 predetermined CAP signal has to be transmitted and the received CAP signal can be measured to determine errors in the received CAP signal.

Illustratively, for channel i , the transmitted CAP signal $a^{(i)}(n)$, after propagating through the channel, is sampled as $a^{(i)}(n)$ at the receiver. The difference between the transmitted CAP signal and the received CAP signal is 15 the difference error. The CAP signal for signal j causes interchannel interference with channel i . If the error is caused by the interference from channel j , through the cross-talk transfer function $H_{ij}(f)$ (i.e., 345_j), this error information can be used to adjust the pre-coder $P_{ij}(f)$, (i.e., 310_j).

The two shaded paths in Figure 3 illustrate interchannel interference. In 20 the first shaded path, transmit signal $a^{(j)}(n)$ propagates through channel j by a path comprising summer function 320_j, transmit filter function 330_j, second channel impairment function 345_j and data slicer function 350_j. At second summer function 350_i, the two CAP signal symbol streams are commingled and received via receiver function 360_i.

25 The difference between the expected signal shape and level and the actual received signal shape and level is determined. In a second shaded path, a pre-coded CAP signal provided by pre-coder function 310_j is propagated through a path comprising summer 320_i, transmit filter function 330_i, and first channel I impairment function 340_i (i.e., $H_{ii}(f)$) and to second I 30 channel summer function 350_i.

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FIG. 3 shows that the effect of pre-coding transfer function $P_{ij}(f)$ (310i) is to cancel the effect due to the cross-talk transfer function $H_{ij}(f)$ (345_j). The sum of the two paths should be zero. Specifically, P_{ij} is adjusted so that the difference between the two signals become zero. That is the two paths should

5 have the opposite transfer function resulting in a sum of zero. Hardware and/or software suitable for realizing the pre-coder function may be implemented using techniques similar to those used for implementing an adaptive canceler.

FIG. 4 depicts a high level block diagram of a multiple channel

10 transmission system according to an embodiment of the present invention. It will be appreciated by those skilled in the art that while the system 400 of FIG. 4 is depicted as including four encoding, transmitting and receiving entities, more or fewer encoding, transmitting and/or receiving entities may be utilized.

Each of the four transmitters depicted in FIG. 4 (denoted as channels A

15 through D) comprises an encoder E that receives a respective bitstream or data signal or DS to be transmitted. The output of each encoder E , illustratively a CAP symbol stream of the form $a^{(x)}(n)$, where x identifies the particular channel, is coupled to a corresponding summer S and to the input of a pre-coder function within each of the other channels.

20 Each of three pre-coder functions (one for every other channel to be processed) used in each channel is used to adapt the encoded symbol stream to a respective one of the three remaining channels. The pre-coder functions are denoted as $P_{xy}(f)$, where x denotes the channel that utilizes the output of the pre-coder function, and y denotes the channel providing input to

25 the pre-coder function. Thus, for example, pre-coder $P_{12}(f)$ receives input from the encoder E_2 of the second channel (i.e., channel B) and provides output to the summer S_1 of the first channel (i.e., channel A).

Each summer S receives the output of its respective encoder E , as well as the output of a respective pre-encoder function ($P_{12}(f)$, $P_{13}(f)$ and $P_{14}(f)$ in the

30 case of channel A) from each of the three other transmission channels. The summer S sums the received signals to produce an output signal of the form

$v^{(1)}(n)$, which is coupled to a transmit filter function $G(f)$. The output of transmit filter function $G(f)$ is propagated to a respective receiver via a respective communications channel.

- Referring to channel A in the system 400 of FIG. 4, the transmitter
- 5 includes an encoder E_1 that produces an encoded symbol stream of the form $a^{(1)}(n)$ in response to a received data signal DS_1 . The encoded symbol stream is provided to a summer S_1 . The summer S_1 also receives three other signals provided by respective pre-coders. A first pre-coder $P_{12}(f)$ receives an encoded signal $a^{(2)}(n)$ produced by an encoder E_2 of the second transmitter.
 - 10 Similarly, the second $P_{13}(f)$ and third $P_{14}(f)$ pre-coders receive encoded signals from the third E_3 and fourth E_4 transmitters. Each of the pre-coders $P_{12}(f)$ through $P_{14}(f)$ provides a respective pre-coded output signal $u^{(12)}(n)$ through $u^{(14)}(n)$ to the summer S_1 . The summer S_1 sums the encoded signal produced by the encoder E_1 and the signals produced by the three pre-coders
 - 15 to produce an output signal $v^{(1)}(n)$ that is coupled to the first transmitter filter $G_1(f)$. The output of the transmitter filter $G_1(f)$ is transmitted by a respective channel to a corresponding receiver $R_1(f)$.

- The transmission channels are depicted as having various channel impairments $H(f)$. Specifically, a transmission channel impairment $H_{11}(f)$
- 20 operates upon data transmitted via the first transmission channel. Similarly, a second channel impairment $H_{12}(f)$ represents the impairment to data within the first transmission channel caused by interference or cross-talk from the second transmission channel. A third impairment channel $H_{13}(f)$ represents the impairment to data within the first transmission channel caused by
 - 25 interference or cross-talk from the third transmission channel. A fourth impairment $H_{14}(f)$ represents the impairment to data within the first transmission channel caused by cross-talk or interference from the fourth transmission channel.

- Each of the channel impairments $H_{11}(f)$ through $H_{14}(f)$ are depicted as
- 30 being summed by a summer SH_1 . It is noted that such summation does not actually exist as a discrete element; rather, the summation function SH_1